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(54) **METHOD FOR FORMING A STEEP EMBANKMENT**

HERSTELLUNGSVERFAHREN FÜR EINE STEILE BÖSCHUNG

PROCEDE DE CONSTRUCTION D'UNE DIGUE INCLINEE

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WO-A-96/33314 **GB-A- 2 283 038**
GB-A- 2 292 763 **GB-A- 2 295 180**

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Description

[0001] This invention concerns a method for constructing a steep embankment or slope. Within the field of civil engineering various techniques are known for building steep slopes. In general, the known techniques stem from the wish to achieve stable slopes since, in many cases, for construction purposes or traffic related reasons it is necessary to execute a given embankment so steep that the embankment cannot be constructed solely with earth or gravel materials and would not in itself be stable enough to resist erosion for a longer period of time. Particularly it cannot resist erosion due to precipitation, including rain showers, the effects of melting water etc. Such an embankment must furthermore in certain cases fulfil specific requirements or wishes with regard to appearance, including vegetation, stone kerbing, wooden or facade coating.

[0002] Examples of the known technical solutions are disclosed in the following patent publications. CH 266 452, DE 20 53 891, FR 1,393,988, US 3,686,873 and 4,117,686, FR 2,303,121, EP 0 197 000, WO 95/00712, EP 0 574 233, GB 2 283 938 and GB 2 292 763. Said Danish patent discloses a technique of applying a specially angled support grid, which is designed with a plane support part and an upwardly sloping front part that is to be constructed with an angle or inclination in relation to the plane base part corresponding to the inclination of the completed embankment relative to horizontal. In accordance with said prior art, geo-nets or geo-textiles are placed in immediate contact with the plane part of the grid, i.e. fixed or clamped thereon.

[0003] This prior art suffers from the serious limitation that the grid utilized must be constructed specifically according to the given application and either has to be transported in its completed form from a place of manufacture to the place of use or, alternatively, must be constructed in the exact form at the site of use. Once the support grid is finished the said prior art does not provide the opportunity of the support grid for a certain use, i.e. during the construction of an embankment, be adapted to accommodate any variations, which may be necessary during the construction work. This, naturally, entails high demands for accuracy both in the planning of the work to be carried out and in the construction of the support grid.

[0004] An object of the present invention is to achieve a technique which eliminates the aforesaid drawback in the prior art, and particularly enables a more flexible adaptation and construction of an embankment on site and at the same time enables the construction of an embankment using a universal set of elements which may be produced with universal dimensions and combined on site according to a given required embodiment, i.e. corresponding to the embankment to be constructed.

[0005] This purpose is achieved by a method according to the present invention for building a steep embankment, comprising the following steps:

(a) digging a trench wherein a planar front grid is erected and secured with sand, gravel, concrete or a combination thereof, the planar front grid having an inclination corresponding to the embankment to be completed and being placed immediately adjacent the front of the embankment to be completed;

(b) placing an anchor element at a point in the earth formation behind the embankment to be completed, the anchor element being constituted by an anchor grid, an anchor peg, an anchor block or the like or a combination thereof;

(c) establishing one or more fixed anchors between the planar front grid and the anchor element by means of one or more anchor braces or struts that secure the front grid in relation to the anchor element; and

(d) filling up the area behind the front grid and covering the anchor element to provide the earth formation of the completed embankment.

[0006] The basis of this invention is the recognition that by using a planar grid constituting a planar front grid in the completed embankment, an anchor element which consist of an anchorage grid, an anchor peg or an anchor block as well as one or more anchorage braces or struts, a reinforcement may be constructed in an embankment, it being possible to construct said reinforcement on site and adapt it to the given specifications and requirements, including ad hoc adjustment. Thus, according to the present invention there are no requirements for a special designing of the components used, including the front grid, the anchor element and the anchoring braces or struts, since these are simply assembled on site by the method according to this invention.

[0007] Erecting of the front grid according to the method of the invention may take place in any suitable way, including fixing of the front grid by means of anchoring pegs driven down at the bottom edge of the front grid once it has been raised to the desired inclination in relation to horizontal and possibly temporarily supported and fixed by means of temporary anchor struts or the like. According to the invention a stable securing of the front grid is carried out by digging a trench prior to or during the erection of the planar front grid and erecting and securing the planar front grid in said trench using sand, gravel, concrete or a mixture thereof. An especially simple way is thus achieved for secure and reliable erection of the front grid with the desired angle in relation to horizontal and thus corresponding to the inclination of the completed embankment.

[0008] The method according to this invention preferably further comprises a step wherein one or more layers of geo-net and one or more layers of geo-textiles which may be mutually interconnected or placed overlapping one another under or above the anchor element

as well as preferably behind the front grid. A fine-meshed linking or weaving of the earth formation with the reinforcement elements applied according to the invention, i.e. in relation to the front grid and the anchor element, is thereby established in the earth fill built up behind the front grid.

[0009] The front grid may constitute a component left in place after construction of the) embankment and, depending on the specific use, it may be made from corrosion-resistant material or alternatively from non corrosion-resistant material. If the front grid is to remain intact as a reinforcement element in the embankment even after a long span of years, the front grid must naturally be made from corrosion-resistant material. In case of subsequent planting and thereby so to say natural reinforcement of the embankment built according to the method of the invention the front grid may be made from non corrosion-resistant material, the front grid corroding away after a period of time.

[0010] If, after building the embankment according to the method of the invention, further reinforcement of the front of the constructed steep embankment is established, the method may, according to an alternative embodiment, further comprise the final step of removing the front grid after construction of the finished embankment, including any planting on the completed embankment.

[0011] The invention will be described in the following with reference to the drawing, in which

fig. 1 is a schematic perspective view of the preferred embodiment of the method according to the invention, in which the anchorage of a front grid is ensured by anchoring grids,

fig. 2 is a schematic perspective view of a first alternative embodiment of the method according to the present invention, in which the anchoring of the front grid is ensured by anchor pegs,

fig. 3 is a schematic perspective view of a second alternative embodiment of the method according to the present invention, in which the anchorage of the front grid is ensured by anchor blocks,

fig. 4 is a schematic cross-section view of a steep embankment according to the present invention built by repetition of the method shown in fig. 1 and having inserted reinforcement nets,

fig. 5 is a schematic cross-section view of a steep embankment with varying level and built according to the method of the present invention,

fig. 6 is a schematic cross-section view of a steep embankment according to the present invention built according to the method of the present invention and having a reinforcement net arranged at a distance rearwards, and

fig. 7 is a schematic cross-section view of a steep embankment according to the present invention built according to the method of the present invention and having an outer coating.

[0012] In the figures the same reference numerals have been used for identical elements fulfilling identical or equivalent functions and located in identical or equivalent positions. The reference numerals carrying a single, double or triple mark designate identical elements in different positions or at different levels.

[0013] In a schematic perspective view fig. 1 shows the preferred embodiment of the method according to the present invention. The method of building steep embankments in earth comprises the digging of a trench 1 having a depth and a width of approximately 30 cm for receiving and securing a front grid 2 at an angle corresponding to that of the completed embankment. The front grid 2 is a per se conventional reinforcement grid made of iron, steel, aluminium or other suitable material or a combination thereof. The front grid may be corrosion resistant in order to impede the decay of the front grid over time or, as an alternative, it may constitute a non corrosion resistant breakable front grid which deliberately decays within a shorter or longer period of time after the embankment has been established. The front grid has a mesh size varying according to the given use between 5 and 50 cm, typically 10-20 cm, like 15 cm. Before the final fixing of the front grid 2 it is secured at the desired angle by means of a temporary bracing 3. Sand, gravel, concrete or a mixture thereof is poured into the trench 1 for securing the front grid 2, and the inclination thereof is stabilized by anchoring on the side where the earth reinforcement is to be made by means of two anchor braces or struts 4a and 4b. At one end the anchor braces or struts 4a and 4b are fixed in the ground by means of a fixing peg or bracket 6 and at the other end they are fixed at the front grid 2 on the same sloping grid line so that the anchor brace or strut 4b is lying on the ground, that the brace or strut 4a forms an angle α less than 90° with the inclined plane of the front grid 2 and that the point of fixture at the front grid is situated at a height less than 0,5 m. It is not a necessary prerequisite that the anchor brace or strut 4b be situated horizontally on the ground and that it be fixed by means of the fixing bracket 6 in the same point as the anchor brace or strut 4a since, depending on the steepness of the embankment and to ensure a better resistance against the shear and tension forces occurring therein, the anchor brace or strut 4b may be secured closer to the front grid but preferably on the same ground projection line of the anchor brace or strut 4a and at an angle β with the front-grid normally smaller than the angle α .

[0014] To ensure the resistance of the completed structure or formation against the tangential shear forces pressing against the front grid 1, the anchor braces or struts are also secured by means of the fixing peg to an anchor element 5 in such a manner that the com-

bined translatory and rotary movement of the anchor braces or struts 4a and 4b is prevented by the resistance of the anchor element 5. To achieve optimum stability properties the anchor element 5 (which may be an anchor grid as in fig. 1, an anchor peg as in fig. 2 or an anchor block as in fig. 3) is placed at a certain distance in the longitudinal direction from the grid, typically a distance of 1-5 m, like 1-3 m, preferably about 1 m. Even though the anchor braces or struts 4a and 4b in fig. 1 are shown secured by means of the fixing peg 6, the anchor braces or struts 4a and 4b may, as an alternative, be secured directly to the anchor element 5.

[0015] It should be noted that the position of the anchor braces or struts 4a and 4b with relation to the anchor grid 5 and the front grid 2 may be changed according to the given use and that according to the given use, a varying number of anchor braces or struts may be used in connection with a front grid depending on the given circumstances, including especially the angle or inclination of the front grid in relation to horizontal and the given soil conditions.

[0016] Fig. 2 is a schematic perspective view of a first alternative embodiment of a method according to the present invention similar to the preferred embodiment shown in fig. 1, but with the front grid 2 anchored by means of anchor pegs 5.

[0017] Fig. 3 is a schematic perspective view of a second alternative embodiment of a method according to the present invention similar to the first alternative embodiment shown in fig. 2, but with the front grid 2 anchored by means of anchor blocks 5.

[0018] Fig. 4 shows a schematic cross-section view of a steep embankment built by repetition of the method described above with reference to fig. 1. For construction of the steep embankment the following steps are carried out:

a trench 1 may optionally be dug for receiving and securing the front grid, said trench being filled with sand, gravel, concrete or a mixture thereof once the front grid 2 has been placed therein,
the front grid 2 is adapted to and maintained at the desired angle by means of the temporary bracing 3, not shown in fig. 4 but shown in fig. 1,
the temporary bracing is removed when the embankment is stable,
a plant mat or geo-textile 8 may be suspended, as shown by dotted lines in fig. 4, by means of net-holders 9, not shown in the drawing, on the inner part of the front grid 2,
reinforcement material 7 is laid on the ground or on the latest compressed layer of earth or gravel and is suspended at a height of approximately 2 m on the inner part of the front grid 2 on the plant mat or geo-textile 8,
the front grid is anchored by means of the anchor braces or struts 4a and 4b which are secured to the ground and the anchor element 5,

a filling up with earth and/or gravel is carried out behind the front grid 2 up to the desired level where the next layer of reinforcement material is to be laid out,

thereafter the suspended reinforcement material is flipped back over the finally compressed layer of earth and/or gravel.

[0019] Hereafter the steps a-h are repeated until the height of the structure corresponds to the desired height of the embankment and it may be covered by the material chosen to serve the desired purpose, e.g asphalt -for road construction- or trees and/or bushes -to prevent landslides. As reinforcement material 7 may instead be used steel net, the mesh size and dimensions of which may vary according to the design.

[0020] When establishing green embankments the plant mat 8 may be a biodegradable coir mat or a geo-textile which is positioned immediately behind the facade of the wall and has the purpose of holding back top soil and which is built into the front of the embankment and of ensuring that the subsequent sowing is bound to the embankment. Special mats of mineral wool may also optionally be used.

[0021] Fig. 5 is a schematic cross-section view of a steep embankment having a displaced front and being built in accordance with the method according to the present invention. As can be seen in fig. 5, the construction of the steep embankment is initiated in the same way as the construction of the embankment shown in fig. 4, but each time the construction of an individual section of the displaced front is started, a new front grid 2' (possibly 2", 2''' etc. not shown in the figure) is positioned at a distance from and rearwardly displaced with respect to the front grid 2. The layer of reinforcing material 7 is countersunk for a distance behind the front grid 2 and dug down at the position where the second front grid 2' is to be installed. The steps to be followed in the construction of the second section of the embankment are identical with those used in the construction of the first level and as many levels as desired may be built. It should be noted that a possible connection may be established between the anchor elements between the various sections of the embankment and in front of the grids by means of separate anchor braces or struts which are not shown in fig. 5.

[0022] Fig. 6 is a schematic cross-section view of a steep embankment built according to the method of the present invention and having a set back reinforcement net 7 and stonework 9. The principle of construction is like the principle described in connection with fig. 5; but the reinforcement net 7, however, is placed at a distance from the front grid 2 to provide space between the front grid 2 and the reinforcement net 7 for filling up with stones simultaneously with the other side of the reinforcement net 7 is filled with earth.

[0023] Fig. 7 is a schematic cross-section view built up in accordance with the method of the present inven-

tion and having an outer coating 10 which is secured by means of brackets 11, which again are anchored in the embankment by means of a number of anchor braces or struts 12. The embankment is otherwise constructed equivalently to the embankment described above with reference to fig. 5, however, without a displaced front.

[0024] According to the present invention the following important advantages are achieved over the prior art. By means of the method an embankment is established in a simple way by means of universally applicable elements, a front grid, an anchor element, a number of anchor braces or struts and one or more layers of geo-net or one or more layers of geo-textiles, said embankment having any inclination and being designed with any desired outward appearance, including planting, coating etc.

[0025] The technique according to the present invention does not set out any specific requirements as to the design of especially configured components such as especially designed support grids, and the erection of the reinforcement system according to the present invention may be carried out according to the given conditions on a plane or slightly sloping ground and may furthermore be directly integrated with already existing facilities.

[0026] Depending on the given conditions, the front grid may be removed after construction of the embankment or alternatively be left within the embankment for subsequent corrosion or alternatively it may serve as formwork during the construction of a coating. When left within the embankment the front grid may furthermore serve as protection against malicious damage, vandalism, erosion etc. for a long span of years.

[0027] If the front grid is either removed or degraded in consequence of corrosion over a number of years, the stability of the embankment is secured by the remaining reinforcement elements, including the anchor element, the geo-nets or the geo-textiles.

[0028] In special cases a facade coating may be designed in the form of stonework, whereupon the reinforcement material should not be visible and this is facilitated by erecting the reinforcement material at a distance behind the front of the completed embankment, whereby the front grid serves to determine the overall stability of the embankment and consequently should be constructed of corrosion-resistant material.

[0029] The technique according to the present invention may furthermore be used for construction of dams and coast protection installations or other similar safety installations.

[0030] Although the invention has been described above with reference to a number of embodiments of the invention, the invention is naturally not limited to said embodiments.

Claims

1. A method of constructing a steep embankment or slope, the method comprising the following steps:

(a) digging a trench wherein a planar front grid is erected and secured with sand, gravel, concrete or a combination thereof, the planar front grid having an inclination corresponding to the embankment to be completed and being placed immediately adjacent the front of the embankment to be completed;

(b) placing an anchor element at a point in the earth formation behind the embankment to be completed, the anchor element being constituted by an anchor grid, an anchor peg, an anchor block or the like or a combination thereof;

(c) establishing one or more fixed anchors between the planar front grid and the anchor element by means of one or more anchor braces or struts that secure the front grid in relation to the anchor element; and

(d) filling up the area behind the front grid and covering the anchor element to provide the earth formation of the completed embankment.

2. A method according to claim 1, **CHARACTERIZED IN that** the method further comprises a step of inserting one or more layers of geo-net or one or more layers of geo-textiles that may be mutually interconnected or overlapping, beneath or above the anchor element and preferably also behind the front grid.

3. A method according to claim 1 or 2, **CHARACTERIZED IN that** the front grid is made of a corrosion-resistant material or, alternatively, a non corrosion-resistant material.

4. A method according to any of the claims 1-3, **CHARACTERIZED IN that** the method further comprises the final step wherein the front grid is removed after construction of the completed embankment and optionally planting on the completed embankment.

Patentansprüche

1. Verfahren zum Aufbau eines steilen Abhanges oder einer Steigung, wobei das Verfahren folgende Stufen umfasst:

(a) Aushebung einer Rinne, in der ein ebenes Vordergitter errichtet und mit Sand, Kies, Beton oder einer Kombination daraus befestigt wird, wobei das ebene Vordergitter eine Neigung

hat, die dem zu vollendeten Abhang entspricht, und unmittelbar angrenzend an die Vorderseite des zu vollendeten Abhanges plaziert ist,

(b) Anbringung eines Verankerungselementes an einer Stelle in der Erdformation hinter dem zu vollendeten Abhang, wobei das Verankerungselement aus einem Verankerungsgitter, einem Verankerungspflock, einem Verankerungsblock oder dergleichen oder einer Kombination daraus besteht, 5 10

(c) Etablierung einer oder mehrerer festen Verankerungen zwischen dem ebenen Vordergitter und dem Verankerungselement durch ein oder mehrere Verankerungssteifen oder -stützen, die das Vordergitter gegenüber dem Verankerungselement festhalten, und 15

(d) Auffüllung des Bereiches hinter dem Vordergitter und Zudeckung des Verankerungselementes zur Herbeischaffung der Erdformation des vollendeten Abhanges. 20

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Verfahren außerdem eine Stufe der Einfügung einer oder mehrerer Schichten Geonetz oder einer oder mehrerer Schichten Geotextilien umfasst, die miteinander verbunden werden oder sich überlappen können, unter oder über das Verankerungselement und vorzugsweise auch hinter das Vordergitter. 25 30

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Vordergitter aus einem korrosionsbeständigen Material oder alternativ einem nicht korrosionsbeständigen Material hergestellt ist. 35

4. Verfahren nach einem der Ansprüche 1-3, **dadurch gekennzeichnet, dass** das Verfahren außerdem die abschließende Stufe umfasst, in der das Vordergitter nach dem Aufbau des vollendeten Abhanges entfernt wird und optionell Bepflanzung des vollendeten Abhanges. 40 45

Revendications

1. Méthode pour la construction d'une pente raide ou d'un escarpement, la méthode comprenant les étapes suivantes: 50

(a) creuser une excavation dans laquelle un grillage frontal plan est placé et fixé avec du sable, du gravier, du béton ou une combinaison de cela, le grillage frontal plan ayant une inclinaison correspondante à la pente à achever et 55

étant placé immédiatement adjacent à la face de la pente à achever;

(b) placer un élément d'ancrage à un point dans la formation de terre derrière la pente à achever, l'élément d'ancrage étant constitué par un grillage d'ancrage, un piquet d'ancrage, un bloc d'ancrage ou analogues ou une combinaison de cela;

(c) établir un ancrage ou plusieurs ancrages fixés entre le grillage frontal plan et l'élément d'ancrage par moyens d'un ou plusieurs étré-sillons ou étais d'ancrage qui fixent le grillage frontal par rapport à l'élément d'ancrage; et

(d) remplir la zone derrière le grillage frontal et couvrir l'élément d'ancrage pour fournir la formation de terre dans la pente achevée.

2. Méthode selon la revendication 1, **CHARACTÉRISÉE** en ce que la méthode comprend en outre une étape d'insertion d'une ou plusieurs couches de géonets ou d'une ou plusieurs couches de géotextiles pouvant être réciproquement liées ou placées en recouvrement, au-dessous ou au-dessus de l'élément d'ancrage et de préférence également derrière le grillage frontal.

3. Méthode selon la revendication 1 ou 2, **CHARACTÉRISÉE** en ce que le grillage frontal est constitué d'un matériau résistant aux corrosions ou alternativement, d'un matériau non résistant aux corrosions.

4. Méthode selon l'une quelconque des revendications 1 à 3, **CHARACTÉRISÉE** en ce que la méthode comprend en outre l'étape finale par laquelle le grillage frontal est retiré après la construction de la pente achevée et éventuellement la mise en place d'une plantation sur la pente achevée.

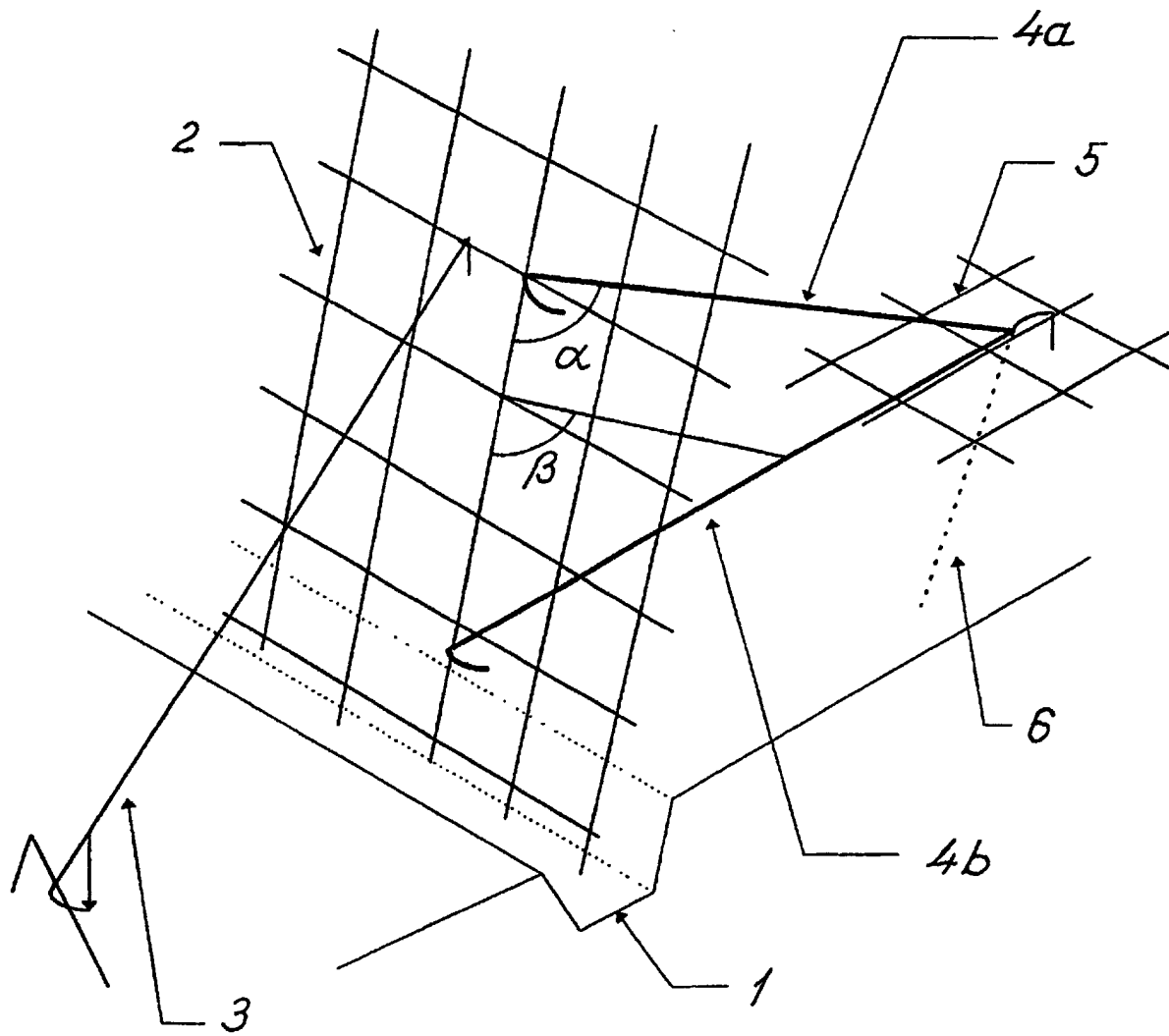


Fig. 1

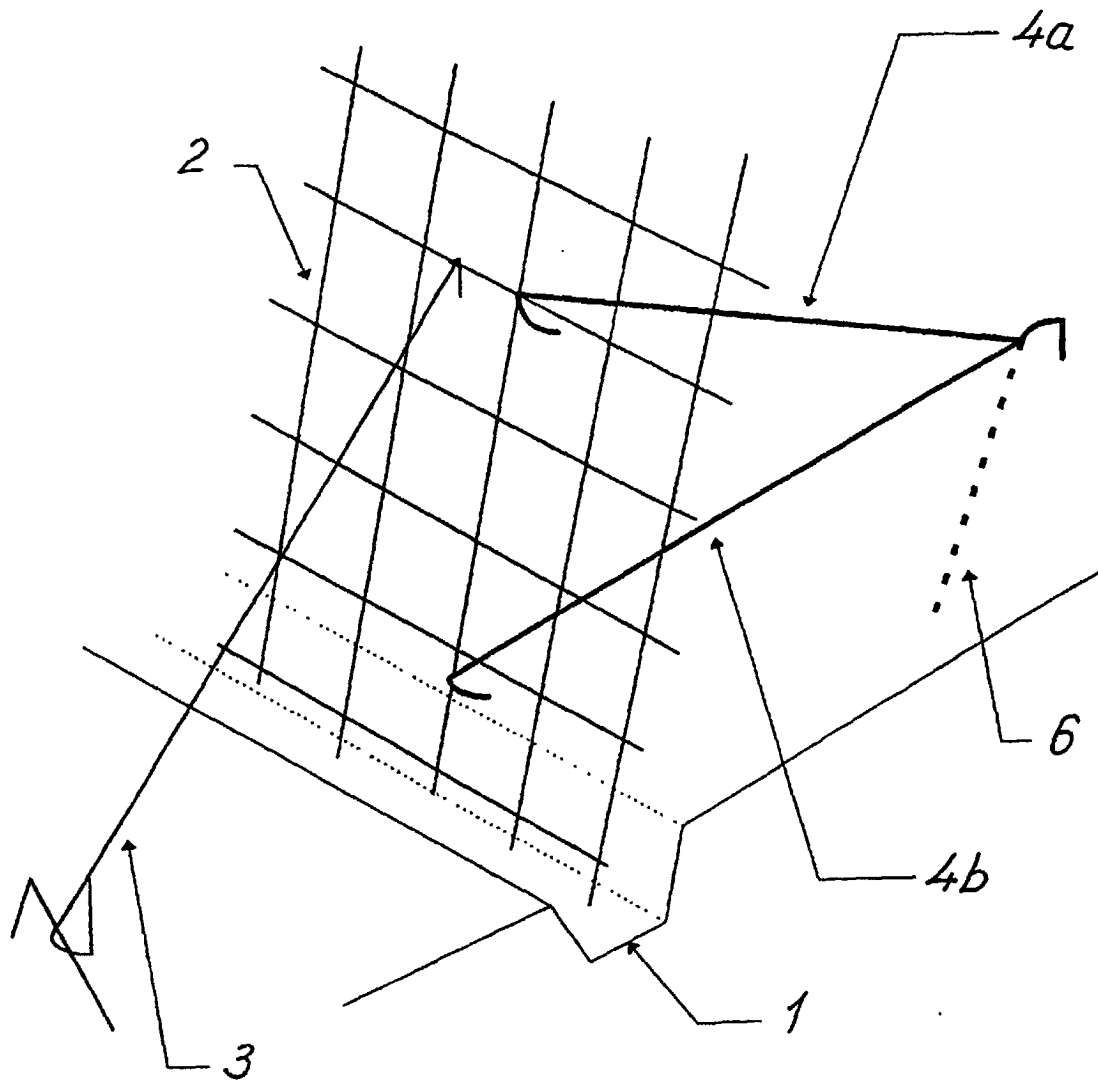


Fig. 2

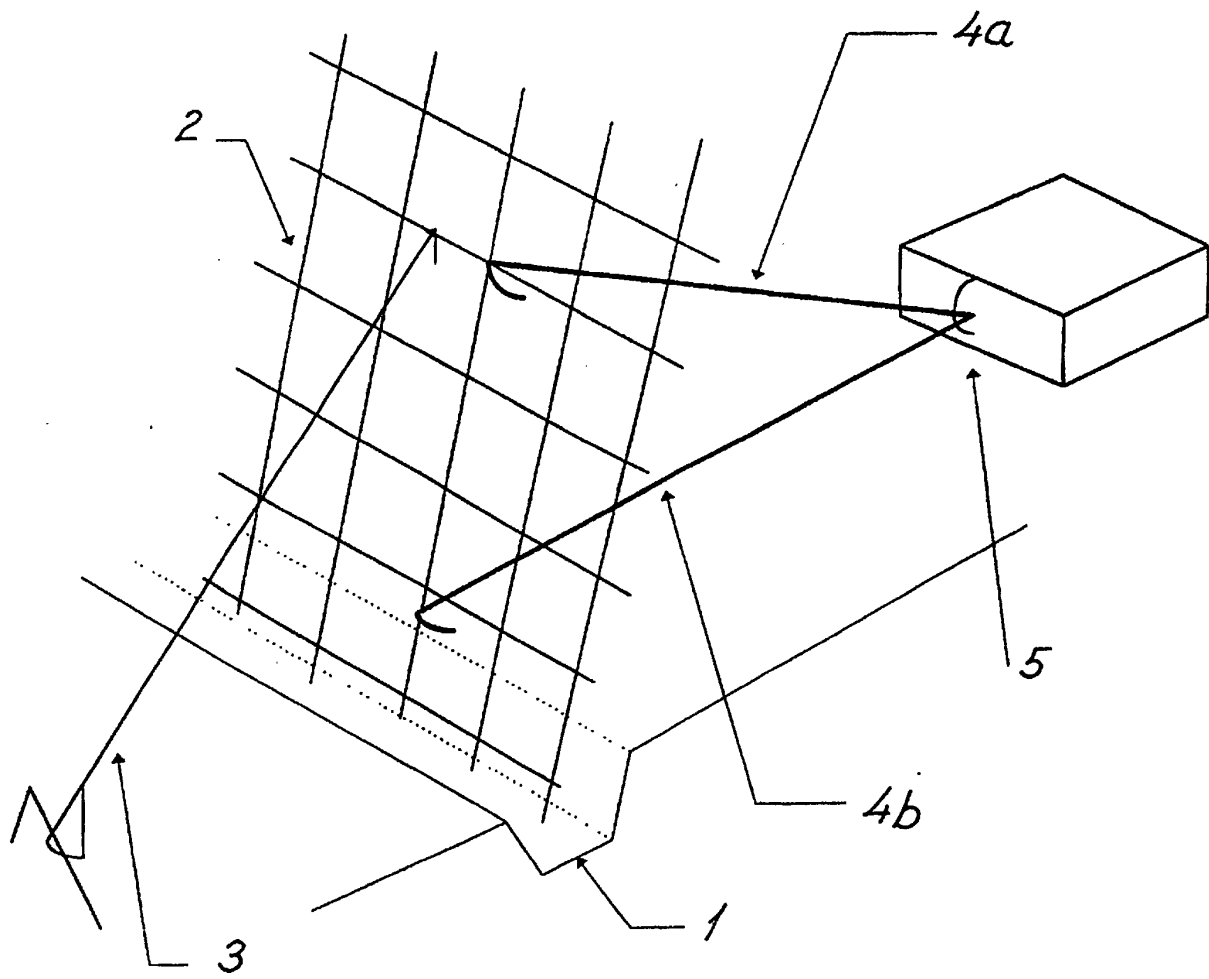


Fig. 3

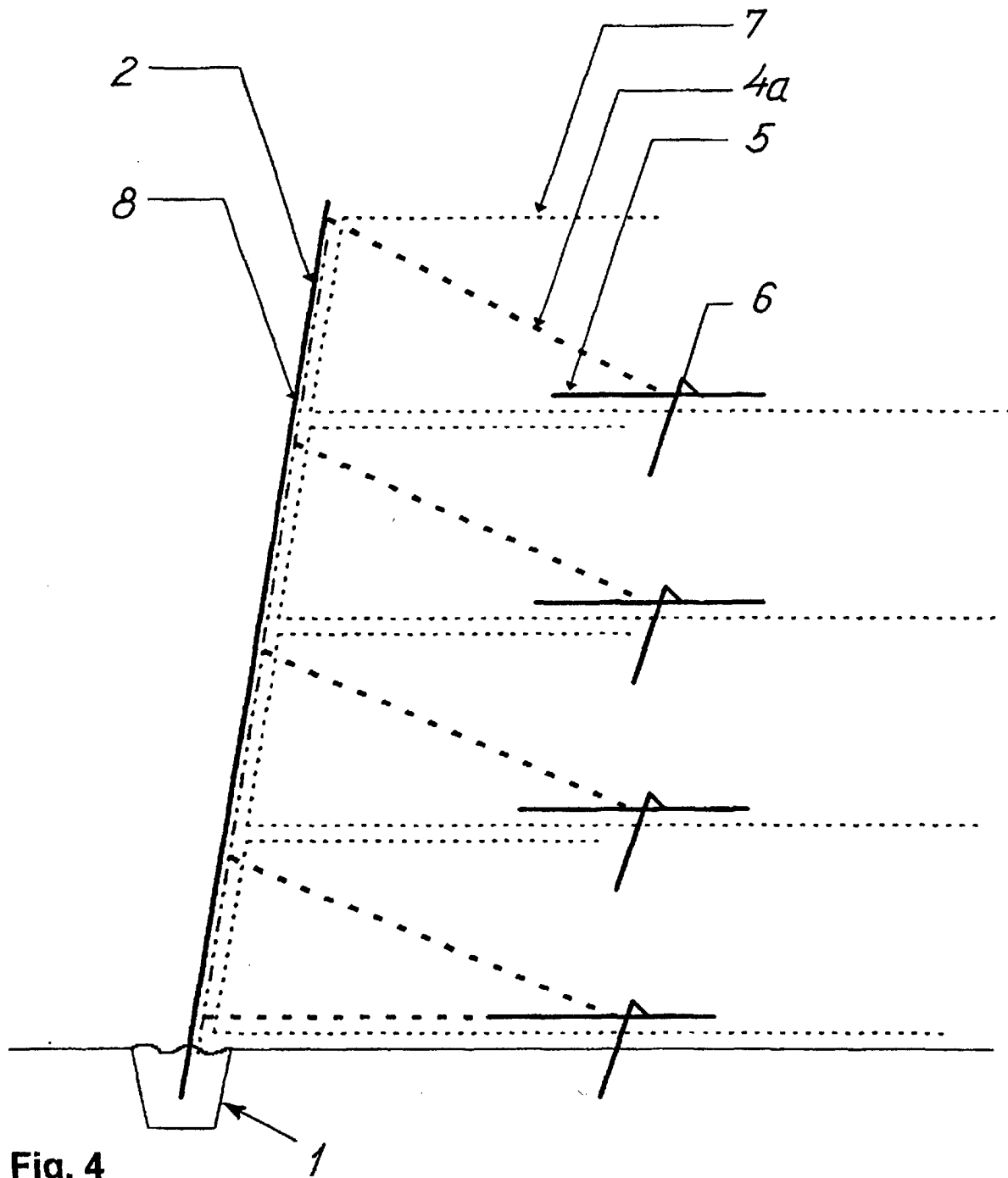


Fig. 4

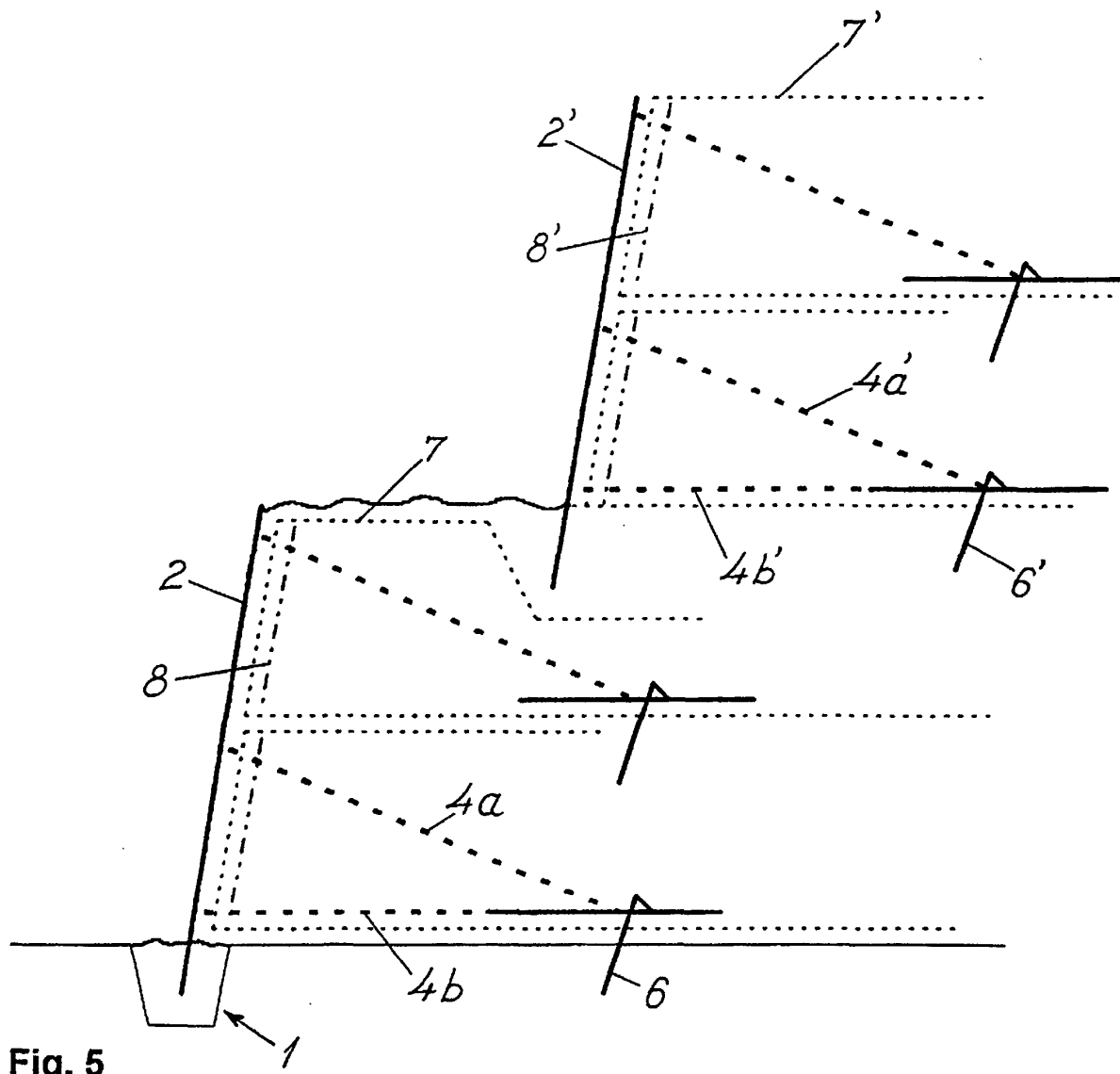


Fig. 5

